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REGRESSION ESTIMATE OF POPULATION SIZE FOR THE CRAB SPIDER *PHILODROMUS CESPITUM* (ARANEAE, PHILODROMIDAE)

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ABSTRACT

A field population of *Philodromus cespitum* (Walckenaer) was used to test Soms' (1978) regression method of analyzing data obtained by removal sampling to obtain a population size estimate. The population density at the study site, as determined by sweep netting, was $1.25/m^2$ on June 18, 1978.

INTRODUCTION

Philodromus cespitum (Walckenaer) is a grass dwelling spider in the family Philodromidae. *P. cespitum* is a holarctic species with a broad American range (Dondale and Redner 1976). This study involves estimation of the population size of *P. cespitum* in a grassy parkland in Milwaukee County, Wisconsin. It represents an attempt to determine whether the sweep netting technique combined with Soms' (1978) regression method of analyzing data obtained by removal sampling as described here could be of value in estimating the size of spider populations.

MATERIALS AND METHODS

The locality where the study was conducted was an unmown area on the Milwaukee River Parkway in Milwaukee County. The vegetation consisted largely of grasses with some forbs intermixed. Scattered sparsely at the site were large sugar maple trees (*Acer saccharum* Marsh). That this is typical *Philodromus cespitum* habitat is supported by reference to Putman (1967), who describes the habitat of this species as "grassy areas, especially near trees" (p. 624) in peach orchards in the Canadian Niagara Peninsula. Also, in contrast to the other *Philodromus* species studied by Putman, *P. cespitum* was not frequently found on trunks and branches of the nearby trees.

A series of sweep-netted samples with collection numbers high enough for application of statistical analysis to obtain a population estimate (at least 20 philodromids in the first sample) was acquired on June 18, 1978. The methodology followed to collect a series of samples for use in estimating population size was similar to that of Menhinick (1963). A 15.24 X 15.24 meter square was roped off at the study site, an area equaling 232.5 m^2. Within this square, I used a 30 cm diameter sweep net with a 1.4 m handle, making 150 sweeps per sampling. The pattern of movement within the square was such that five 3.048-meter wide lanes were swept in 30 sweeps each. After the 150 sweeps had been made, the contents of the net were emptied into a plastic bag and poisoned with ethyl acetate. Spiders were removed and placed in 70% isopropanol. For the purpose of applying the regression method of Soms (1978) to obtain a population estimate, a series of six successive samplings were made. The series of numbers representing the individuals caught in the successive samplings was then subjected to the statistical analysis.

The series of numbers representing the individuals caught in the successive samples for each date were analyzed using the regression method of Soms (1978) where:

$\hat{p}$, probability of capture = $1 - \hat{q}$,

$\hat{q} = \Pi n_i^{c_i}$,

n_i = the number of individuals caught in sampling i,

$c_i = (i - \frac{k-1}{2})/(k(k^2 - 1)/12)$, k equaling the number of sampling periods,

$s_{\hat{p}}^2$, the variance of the probability of capture = $(\hat{q}^2/\hat{m}) \sum_1^k c_i^2/\hat{p}_i$,

$\hat{m}$, the population estimate = $\sum_1^k n_i/(1 - \hat{q}^k)$,

$s_{\hat{m}}^2$, the variance of the population estimate =

$$\frac{\hat{m}\hat{q}^k}{1 - \hat{q}^k} \left[\frac{1 + k^2 \hat{q}^k}{1 - \hat{q}^k} \sum_1^k \frac{c_i^2}{\hat{p}_i} \right]$$

and the 100 $(1 - \alpha)$% confidence intervals for p and m are

$\hat{p} \pm z_{\alpha/2}\, s_{\hat{p}}$ and

$\hat{m} \pm z_{\alpha/2}\, s_{\hat{m}}$

where $z_{\alpha/2}$ is the 100 $\alpha/2$ upper percentile of the standard normal.

RESULTS

The June 18 data set has k = 6 and $(n_1, n_2, n_3, n_4, n_5, n_6) = (42, 28, 35, 21, 24, 22)$ with $\sum_1^k n_i = 172$. The regression method of Soms (1978) gave an estimated population size of 335 ± 89.8. This is a density of 1.44/m^2 for that date. The 95% confidence interval for the June 18 estimate is 155.4 to 514.6. The 95% confidence interval for the June 18 density is 0.668 to 2.21/m^2. This method of analysis gives a probability of

Table 1.–Estimators resulting from the regression technique applied to a population of *Philodromus cespitum* (Walckenaer) in Milwaukee County, Wisconsin June 18, 1978.

Estimators for k=6	18 June 1978
$\hat{p}$ (probability of capture)	0.113
s.d. (standard deviation)	0.041
$\hat{m}$ (population estimate)	335
s.d. (standard deviation)	89.8
Test of Fit	
Z	3.48
d.f. (degrees of freedom)	4.03
$0.25<P(X^2 \geqslant 3.48)<0.50$, for d.f.=4	
Individuals per Sq. Meter	1.44
95% Confidence Interval	0.668-2.21
Estimators for pooled k=2	
$\hat{m}$ (population estimate)	290
s.d. (standard deviation)	63.9
Individuals per Sq. Meter	1.25
95% Confidence Interval	0.698-1.80

capture estimate of 0.113 ± 0.041. The 95% confidence interval for the probability of capture is 0.031 to 0.195. The test of fit, Z, for June 18 is 3.48 with 4.03 degrees of freedom. On the X^2 tables, this test of fit figure gives the following: for June 18, $0.25 < P(X^2 \geqslant 3.48) < 0.50$. Thus the observed values correspond to those expected.

The low value for the probability of capture estimate for the June 18 data set indicates some degree of bias. It is therefore desirable to pool the n_i, using k = 2. After this was done, the estimate of m was 290, with s.d. 63.9. This new estimate gave a less biased density of $1.25/m^2$. The calculation of 95% confidence intervals for this pooled June 18 data set gives an interval of 162.2 to 417.8 for the population estimate and an interval of 0.698 to $1.80/m^2$ for the density.

Zippin (1956) has pointed out that the removal method, to be reasonably precise, requires a coefficient of variation (c.v. = standard error/estimate x 100) of 30% or less. For the June 18 data, c.v. - 63.9/290 x 100 = 22%, giving acceptable precision. On June 18, 59% (172/290) of the spiders were removed from the population.

Results are also shown in Table 1.

DISCUSSION

No fully satisfactory method exists for estimating spider population density. Casual observations in the field may show a certain species to be relatively abundant, but obtaining a quantitative statement of abundance requires techniques that often were developed for larger and/or more easily enumerated organisms. A review of various methods and their limitations is given by Southwood (1968).

Mark-recapture is one of the popular methods of making animal population size estimates. The use of mark-recapture on spider populations, however, has more often been to investigate features such as range size (Hallander 1967) and niche relationships (Kuenzler 1958) rather than to estimate population size. The difficulty of handling smaller spiders without injuring them also tends to confine this sort of method to larger species like the wolf spiders (Lycosidae) that were the subjects of the Hallander and Kuenzler studies.

Also, since this method requires the release of the captured individuals, other potential studies requiring the measurement of spiders in the sample would not be as feasible.

Another technique that has been used by animal ecologists is that of removal trapping. Removal trapping entails a series of sampling periods. At each sampling period animals are removed so that there is a successive reduction in population. A regression analysis of the sequence of numbers of animals obtained during this series of sampling periods enables one to obtain an estimate of the size of the population in the study area. Papers dealing with the statistical analysis of data collected by the removal method are: Carle and Strub (1978), Moran (1951), Soms (1978) and Zippin (1956, 1958) and pages 44-50 of Otis *et al.* (1978).

There can be several different approaches to the analysis of the data gained by removal sampling. The technique used by Menhinick (1963) to arrive at a population estimate is a graphical one. A. P. Soms has subsequently devised a computationally simpler regression technique, one that is based on the limiting distribution of the multinomial, and a short computer program for arriving at the appropriate regression estimators. Soms' (1978) alternative method also avoids statistical deficiencies inherent in other approaches such as that based on the maximum likelihood and allows for pooling when sample sizes are small. Besides a population size estimate and its standard error, Soms' method gives the estimated probability of capture and its standard error, allowing for calculation of 95% confidence intervals, and includes a test of fit.

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